Bio-Gas Use Options

Presented At:
Bio-Energy Production
Through
Anaerobic Digester Technology
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Energy Recovery – Biogas
(60% to 65% Methane)

- Flare It Ø
- Use It for Heating
  - Displace Natural Gas / Propane
- Use It for CHP
  - Displace Purchased Electricity
  - Displace Natural Gas / Propane
- Clean It Up for Pipeline Use

CHP – The Concept

Conventional Energy System

- Customer purchases power from grid (central station)
  - ✓Power plant economy of scale
  - ✓10 units of fuel produces 3 units of power (kW)
  - ✓No recovery of low/medium grade heat
- On-site generation of steam/hot water (boilers/furnaces)
  - ✓10 units of fuel produces 6-8 units of heat (Btus/hr)
- Typical grid power + on-site heat
  - ✓Efficiency depends on heat/power ratio
  - ✓40 to 55% energy efficiency is common

Distributed Generation

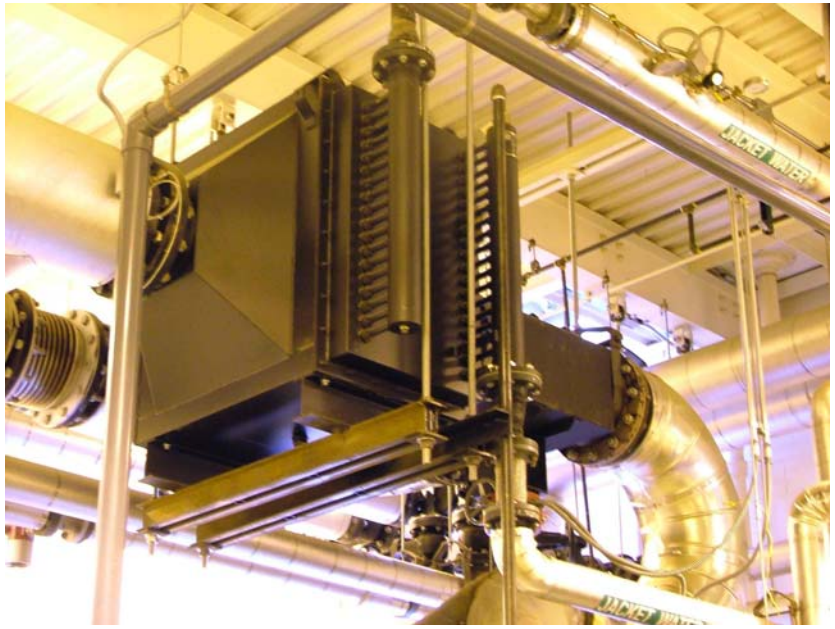
DG is …

- An Electric Generator
- Located At a Substation or Near a Building / Facility
- Generates at least a portion of the Electric Load

DG Technologies …..

- Solar Photovoltaic
- Wind Turbines
- Engine Generator Sets
- Turbine Generator Sets
  - Combustion Turbines
  - Micro-Turbines
  - Steam Turbines
- Fuel Cells

Combined Heat & Power (CHP)
A Form of Distributed Generation

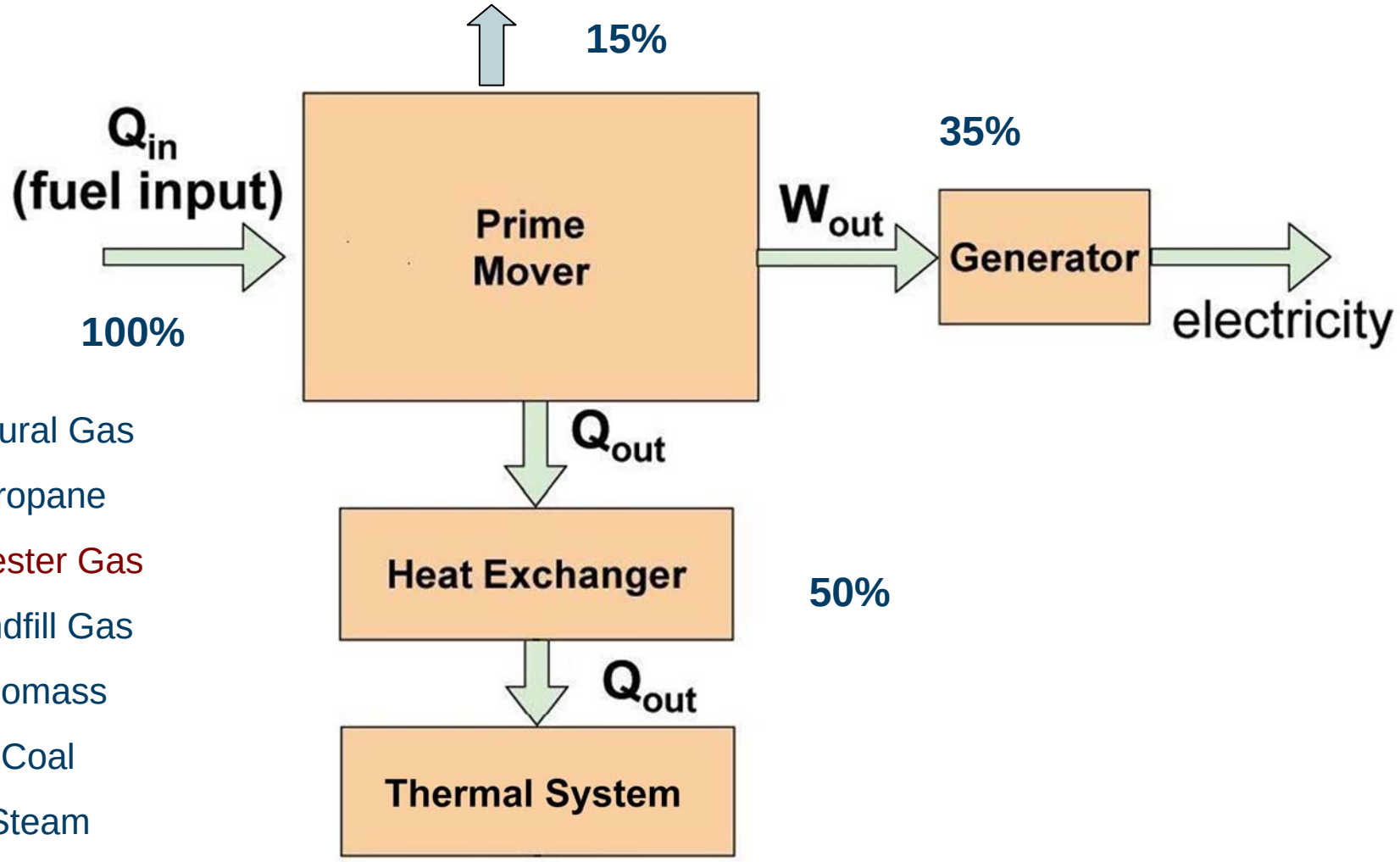


CHP is …

- An Integrated System
- Located At or Near a Building/Facility
- Provides at Least a Portion of the Electrical Load and
- Recycles the Thermal Energy for
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification

Picture Courtesy of UIC

Combined Heat and Power



Natural Gas

Propane

Digester Gas

Landfill Gas

Biomass

Coal

Steam

Waste Products

Others

Normal CHP Configuration

- CHP Systems are Normally Installed in Parallel with the Electric Grid (CHP does not replace the grid)
- Both the CHP and Grid Supply Electricity to the Customer (enhanced reliability)
- Recycled Heat From the Prime Mover Used for:
  - Space Heating (Steam or Hot Water Loop)
  - Space Cooling (Absorption Chiller)
  - Process Heating and/or Cooling
  - Dehumidification (Desiccant Regeneration)

Generators and Inverters

Two Types of Generators

Induction

- Requires External Power Source to Operate (Grid)
- When Grid Goes Down, CHP System Goes Down
- Less Complicated & Less Costly to Interconnect
- Preferred by Utilities

Synchronous

- Self Excited (Does Not Need Grid to Operate)
- CHP System can Continue to Operate thru Grid Outages
- More Complicated & Costly to Interconnect (Safety)
- Preferred by CHP Customers

What Makes A Good CHP Application?

- Good Coincidence Between Electric and Thermal Loads
- Large Cost Differential Between Electricity (Grid) and CHP Fuel --- “Spark Spread”
- Fair / Favorable Regulatory Environment
- Long Operating Hours
- Economic Value of Power Reliability is High
- Installed Cost Differential Between a Conventional and a CHP System (*smaller is better*)

Candidate Applications for CHP

- Hospitals
- Colleges / Universities
- High Schools
- Residential Confinement
- High Rise Hotels
- Fitness Centers
- Food Processing Waste
- Farm Livestock Waste
- Waste Water Treatment
- Landfill Sites
- Pulp & Paper Mills
- Chemicals Manufacturing
- Metal Fabrication
- Ethanol / Biodiesel Plants

What are the Customer Benefits of CHP?

CHP does not make sense in all applications, but where it does make technical and economic sense, it will provide

- Lower Energy Costs
- Reduced Energy Consumption
- Increased Electric Reliability
- Standby Power
- Improved Environmental Quality

Installed CHP

- 82,400 MW at approx. 3000 sites (Nationally)
- Represents approx. 9% of total US generating capacity
- Saves an estimated 3 Quads of fuel per year
- Eliminates over 400 million tons of CO_2 emissions annually

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CHP In The Midwest States

Total Installed Capacity

- **Michigan** **3,086 MW**
- Indiana 1,875 MW
- Wisconsin 1,278 MW
- Illinois 1,239 MW
- Minnesota 1,021 MW
- Ohio 436 MW
- Iowa 382 MW
- Missouri 193 MW

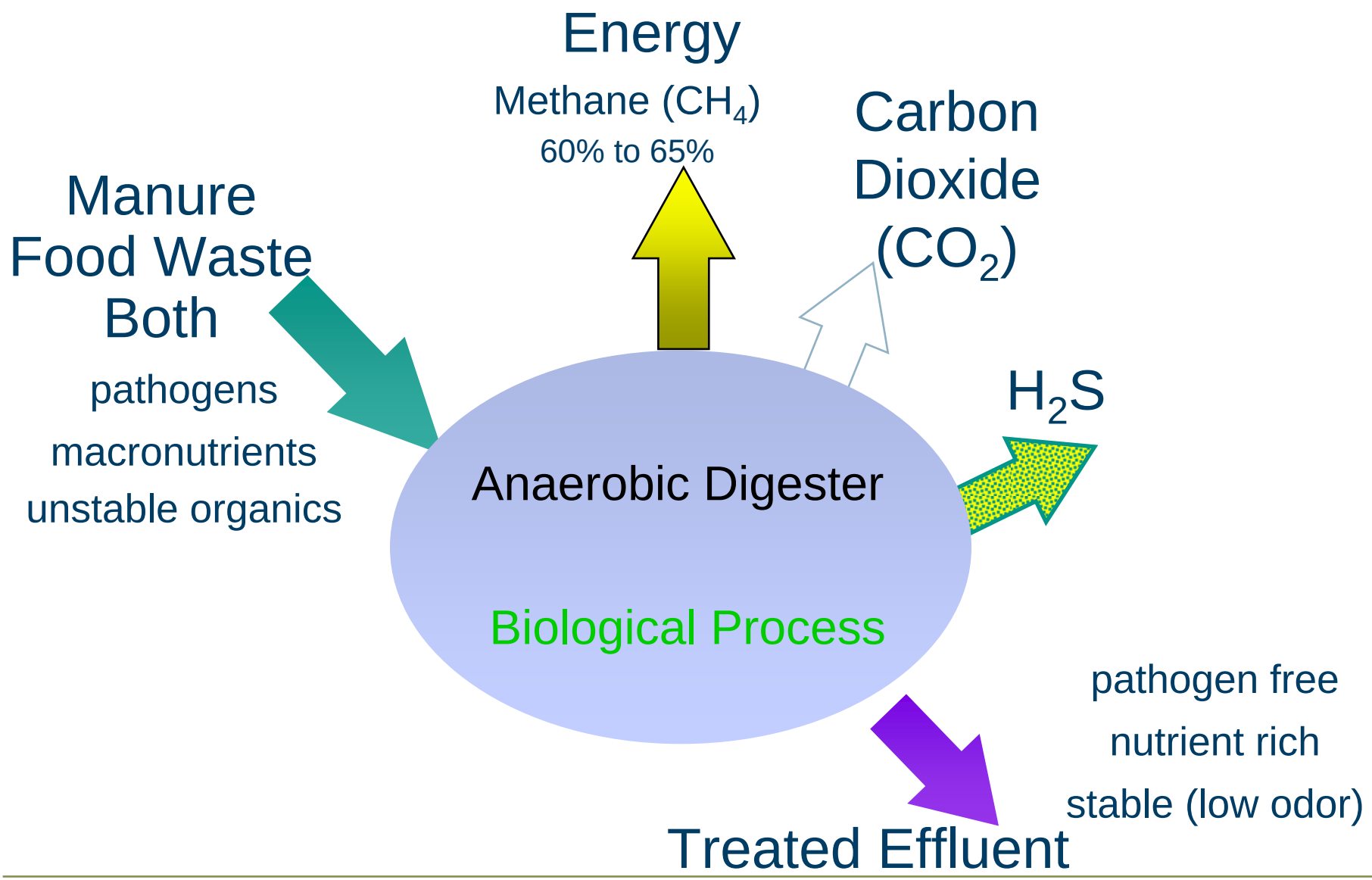
% of Total Electric Generation Capacity in the State

Michigan	**10.5%**
Wisconsin	9.0%
Minnesota	9.0%
Indiana	7.4%
Iowa	4.1%
Illinois	2.8%
Ohio	1.4%
Missouri	1.0%

Biogas CHP Applications (Digester Gas)

- Animal Waste / Manure Management
- Food Processing Waste
- Waste Water Treatment Facilities

Anaerobic Digestion Process Overview



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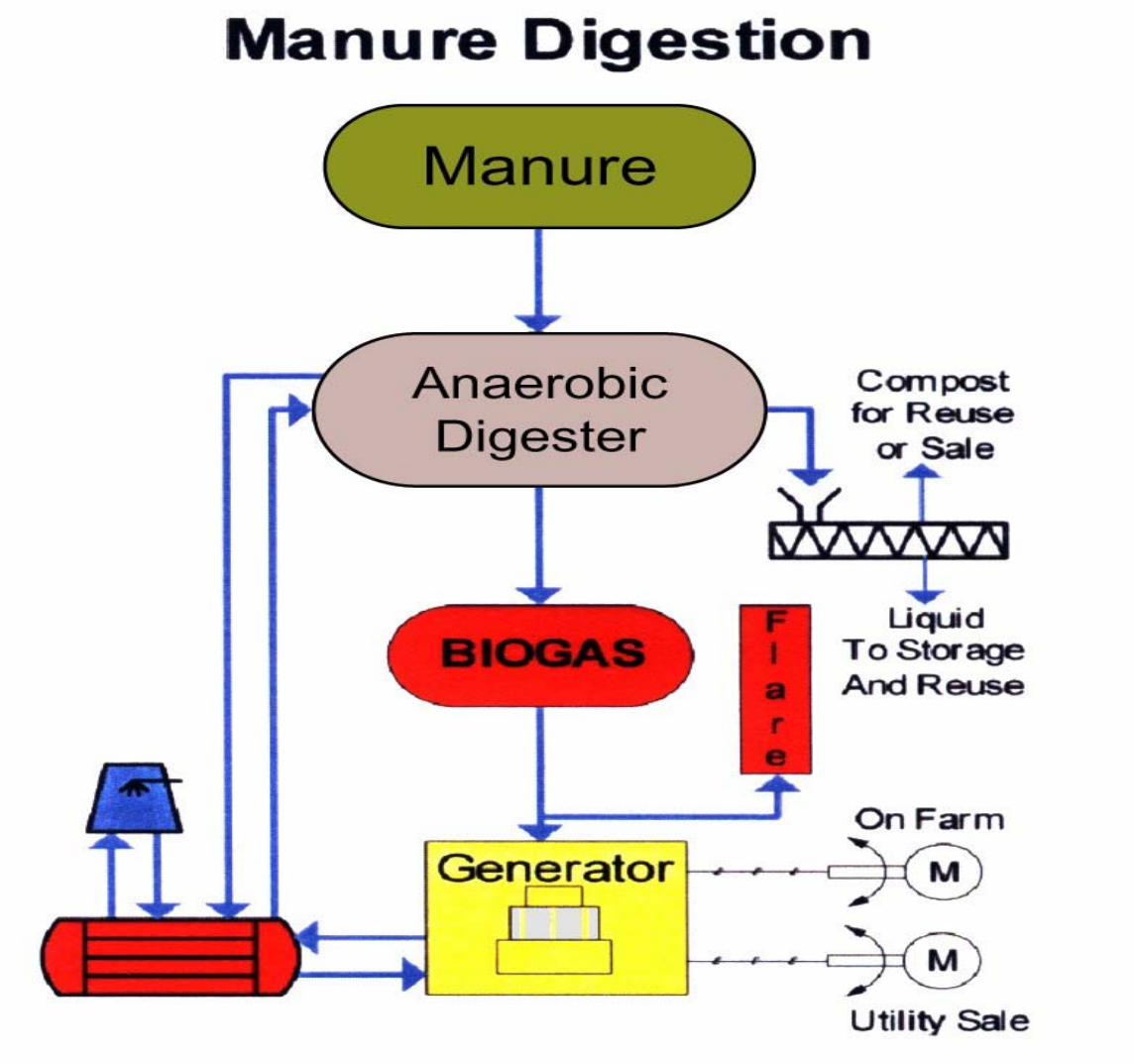
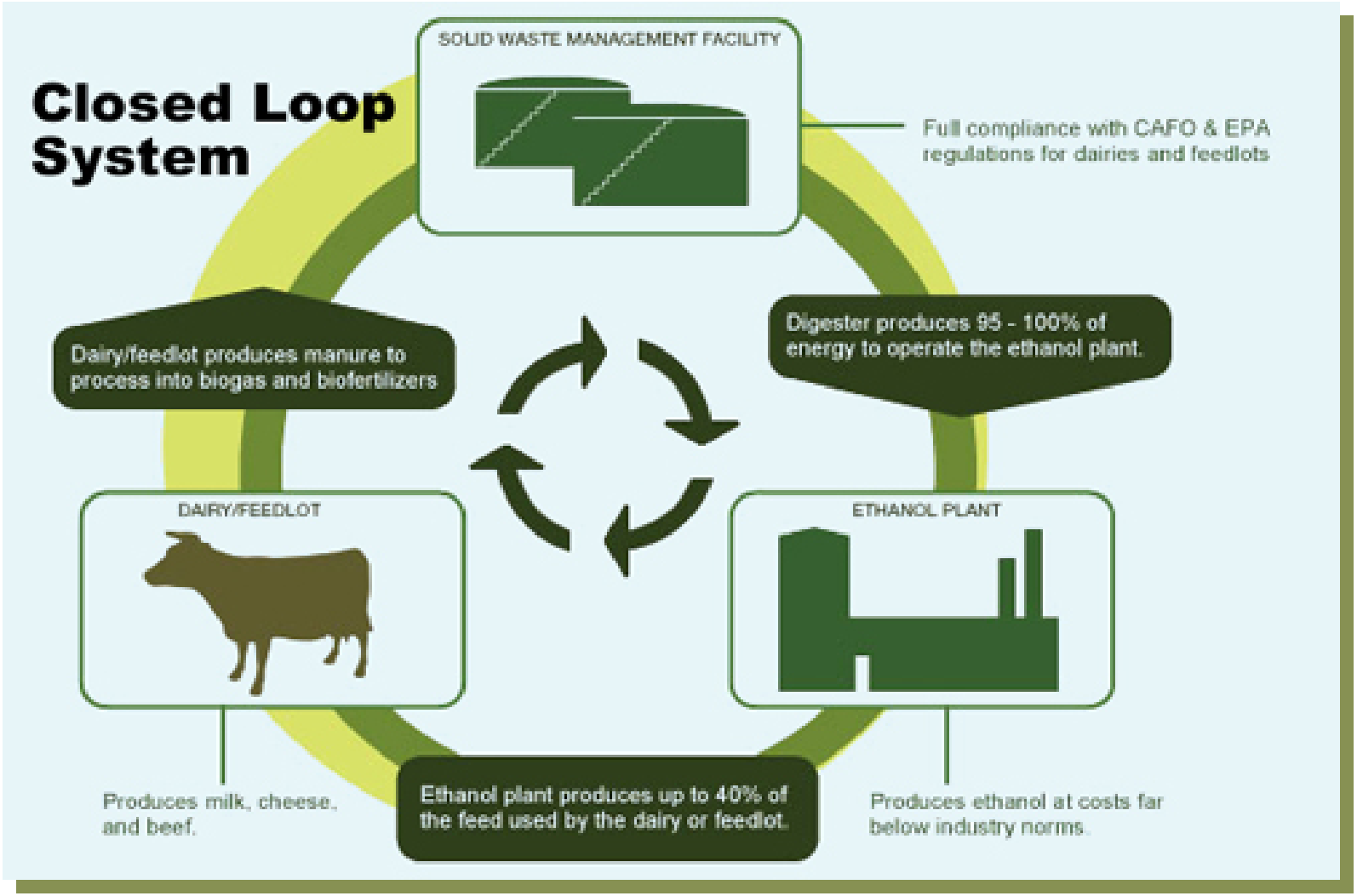
Anaerobic Digester / CHP System



CHP Technologies
(Biogas Applications)

- Prime Movers:
  - Reciprocating Engines
  - Micro-turbines
- Gas Clean up (H_2S) – certainly for micro-turbines
- Gas Compression (micro-turbines)
- Generator / Heat Recovery
- Grid Interconnect Hardware – can be the biggest issue

E³ BioFuels
Mead, Nebraska Ethanol Plant



Pipeline Quality Gas

- Must Remove H_2O, H_2S, and CO_2
- Experience to Date:
  - Stage 1: 86% Methane required for injection in transmission pipeline – high dilution rates
  - Stage 2: 94+% Methane most probably required for distribution line injection
- Biogas Injection Specs being written by Gas Technology Institute (GTI)

CO_2 Removal

- Most Common Technology – Pressure Swing Adsorption (PSA)
  - Biogas, under pressure, is pumped into a cylinder which contains beads of adsorbent material
  - The CO_2 is adsorbed onto the surface of the beads and the purified gas is removed.
  - Pressure in the cylinder is reduced, releasing the impurities from the beads
  - Regenerate by forcing the CO_2 out of the cylinder and start the process again
  - Process may have several cylinders in series
- Water Wash Technology

Questions on Gas Injection Option

- Cost of cleanup – the larger the gas volume, the more cost competitive
- Gas company cooperation – experimental today, injection into pipeline (large dilution)
- Biogas injection specs being developed, a somewhat unknown? (Level of cleanup, cost to meet specs, etc)
- Gas injection not a “slam dunk” approach either

Advantages & Disadvantages
Anaerobic Digesters and Biogas Use

Advantages

- Odor & Insect Mitigation
- Nutrient Management
- Pathogen Reduction
- Energy Savings
- Heating Fuel Savings
- Reduced Electric Bills (CHP)
- Qualified for Net Metering
- Potential Farm Bill Funding

Disadvantages

- Adding Complexity to Farming
- Commitment to Digester System Management (labor & maintenance)
- Commitment to CHP and/or Gas Cleanup System Maintenance
- Capital Costs
- Utility Interconnect (electric or gas) can be Tedious

Expanded Applications

- Adding Food Processing Waste to a Manure System Can Increase Biogas Production with Higher Methane Content – Co-digesting

- Tipping Fees Normal for Handling Food Wastes

- Bedding Material / Compost (potential revenues)

Potential U.S. Market Anaerobic Digester Gas

- Over 3 GW of Potential Capacity
  - 7,000 Dairy Farms
  - 11,000 Hog Farms
  - 6,800 WWTPs

Source: Resource Dynamics Corp.
"Opportunity Fuels for CHP" www.rdcnet.com

Summary CHP / Digester Applications

- Appropriate when digester being installed for odor mitigation or other reasons
- Good match for thermal energy (digester)
- Significant market (manure, food processing, waste water treatment)
- Turn an operational cost (waste product) into a revenue resource
- Farm Bill and Net Metering add incentives
- Reasonable paybacks (6 years possible w/o grants)

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Questions / Discussion